

# Navy-IGDR Users Handbook

April 13, 2000

Unclassified

## Naval Oceanographic Office

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## **Navy-IGDR Users Handbook**

### **1.0 INTRODUCTION**

#### **1.1 Purpose**

The purpose of this document is to provide a description of the GEOSAT Follow-On (GFO) Navy Interim Geophysical Data Record (NGDR). The NGDR is generated from data in the Altimeter Data Fusion Center (ADFC) Oracle database. This database is loaded with data from various sources such as the GFO Sensor Data Record ([SDR](#)), environmental model output, and ephemeris information.

#### **1.2 Change Control**

This document will be under change control of the NAVOCEANO ADFC Change Review Board (CRB). All requests for changes should be submitted to the CRB Chairmen, the N63 Remote Sensing Division, and the N21 Satellite

Analysis and Models Division

1.3 Reference Documents

GDR Users Handbook, Post Verification Draft 2, Section 1-5, Jet Propulsion Laboratory, October 7, 1993.

1.4 Nomenclature

An altimetry file (such as an **SDR** or NGDR) is generally made up of a descriptive header followed by several data records. The header may be comprised of ASCII text or binary data, while the data records are usually binary. These items are broken down as follows:

ITEM		DEFINITION
1. 0	Header	The first major file element. It contains general information about the file and is the first element of the file.
1.1.1	Line	A major header data item composed of ASCII text (usually terminated by a newline).
1.1.2	Record	A major header data item which may be ASCII or binary. Depending on the context, "record" may be used interchangeably with "line".
1.2	Field	A minor header data item which comprises part of a record (or line). Referencing a "field" usually requires that the corresponding record be specified.
2.0	Data Record	The second major file element. It contains unique file information and may be indexed by time or position, etc. Data records are usually binary. Depending on the context, "record" may be used interchangeably with "data record".
2.1	Field	A minor data record item. Referencing a "field" usually requires that the corresponding data record be specified.

Table 1.4-1 Altimetry File Nomenclature

When square brackets "[ ]" follow a data item they are used to indicate the item's units. For example, "SSHC [mm]" would indicate that the quantity SSHC has units of millimeters.

2.0 DATA CONTENT

2.1 General

GFO NGDR filenames have the following format:

ngdr\_gfoX\_YYYYDDD\_Starttime\_Stoptime ,

where

- "X" identifies the ephemeris source
- "YYYY" is the year of data aquisition
- "DDD" is the corresponding day-of-year of data aquisition
- "Starttime" is the UTC midframe time of the first Data Record
- "Stoptime" is the UTC midframe time of the last Data Record

The ephemeris source, "X", can have the following (one character) values:

n=NAVSPASUR , o=OODD , p=PODD , M=MOESLR , P=POESLR

(refer to [section 2.2.2 KEYWORDS](#))

"YYYY" and "DDD" are set equal to the fields "Year" and "Day of Year" from the [SDR](#) header.

"Starttime" and "Stoptime" are five digit integers truncated to units of seconds.

Each NGDR is comprised of a multi-line ASCII header followed by multiple binary data records made up of various fields.

Fields with bad values or missing data are set to the following values:

Data Type	Hexadecimal (base 16)	Decimal (base 10)
8 bit signed integer	7F	127
8 bit unsigned integer	FF	255
16 bit signed integer	7FFF	32767
16 bit unsigned integer	FFFF	65535
32 bit signed integer	7FFFFFFF	2147483647
32 bit unsigned integer	FFFFFFFF	4294967295

Table 2.1-1 Default Values for Bad or Missing Data

Flag fields whose bit values are missing or not set, contain a 0. These correspond to fields 34-36 and 72-75 of the Data Record.

The NGDR records have been checked against the World Data Bank II (WDBII) landmask to remove any points over land. WDBII is a one-minute landmask based on the CIA World Vector Shoreline (WVS).

## 2.2 Header

**Format:** Twenty lines of ASCII text terminated by linefeeds. For lines 1 through 19 a semicolon ";" marks the end of the text string.

**Description:**

Record #	Record Identifier	Description	Units
1	" <a href="#">PASS_BEGIN_TIME</a> = "	UTC Beginning of Frame	seconds
2	"REVOLUTION_NUMBER = "	Revolution Number	N/A
3	"CYCLE_NUMBER = "	Cycle Number	N/A
4	"PASS_NUMBER = "	Pass In Cycle	N/A

5	" <a href="#">PROCESSING_TIME</a> = "	Days since January 1, 1985 UTC	days
6	"PROCESSING_CENTER = "	Processing Center	N/A
7	"SOFTWARE_VERSION = "	Software Version	N/A
8	"SATELLITE_ID = "	Satellite Identification	N/A
9	" <a href="#">DATA_RECORD_LENGTH</a> = "	Total Length of Data Record	bytes
10	"BASIC_GDR_LENGTH = "	Length of Common Portion of Data Record	bytes
11	"HEIGHT_CALIBRATION_BIAS = "	Height Calibration Bias	mm
12	"ALTITUDE_BIAS_INITIAL = "	Altitude Bias Initial Correction	km
13	"ALTITUDE_BIAS_CENTER_OF_GRAVITY = "	Altitude Bias Center of Gravity Correction	mm
14	"SWH_BIAS_INITIAL = "	SWH Bias	mm
15	"AGC_CALIBRATION_BIAS = "	AGC Calibration Bias	dB
16	"AGC_BIAS_INITIAL = "	AGC Bias Initial	dB
17	<a href="#">KEYWORDS</a>	First Comment Line	N/A
18	N/A	Second Comment Line	N/A
19	N/A	Third Comment Line	N/A
20	"END_OF_HEADER"	Last Record in Header	N/A

Table 2.2-1 Header Description

Many of the fields in the NGDR header are derived from (or set equal to) fields in the [SDR](#) Header.

The following sections describe the NGDR header lines listed in the table above.

### 2.2.1 PASS\_BEGIN\_TIME

PASS\_BEGIN\_TIME [seconds] is set equal to the first "SDR Start UTC" of the day (from field 9 of the Header from the first SDR of the day). This corresponds to the UTC time of the first RA data sample of the day (i.e. the first sample in the first high-rate data set (sample 1 of 10)).

This time will correspond to the first high-rate sample in the first data record of the NGDR only if 1) the corresponding SDR point is over water and 2) the NGDR is created from (a) the first SDR file of the day or (b) all the SDR files for the day.

### 2.2.2 REVOLUTION\_NUMBER

REVOLUTION\_NUMBER is not used at this time and is set to the default value for a 32 bit signed integer (see [table 2.1-1](#)).

### **2.2.3 CYCLE\_NUMBER**

CYCLE\_NUMBER is not used at this time and is set to the default value for a 32 bit signed integer (see [table 2.1-1](#)).

### **2.2.4 PASS\_NUMBER**

PASS\_NUMBER is not used at this time and is set to the default value for a 32 bit signed integer (see [table 2.1-1](#)).

### **2.2.5 PROCESSING\_TIME**

PROCESSING\_TIME [days] is the time at which the NGDR was processed (created). It is a floating point number representing the number of days since January 1, 1985, 0.0 hours UTC.

### **2.2.6 PROCESSING\_CENTER**

PROCESSING\_CENTER is an alphanumeric string telling where the NGDR was created, e.g. "NAVO ADFC".

### **2.2.7 SOFTWARE\_VERSION**

SOFTWARE\_VERSION is an alphanumeric string telling the current version of the NGDR processing software.

### **2.2.8 SATELLITE\_ID**

SATELLITE\_ID is an alphanumeric string telling which satellite was processed, e.g. "GFO".

### **2.2.9 DATA\_RECORD\_LENGTH**

DATA\_RECORD\_LENGTH [bytes] is an integer representing the length in bytes of the total NGDR Data Record.

### **2.2.10 BASIC\_GDR\_LENGTH**

BASIC\_GDR\_LENGTH [bytes] is an integer representing the length in bytes of the portion of the NGDR Data Record which is common between all NGDR files for different satellites.

### **2.2.11 HEIGHT\_CALIBRATION\_BIAS**

HEIGHT\_CALIBRATION\_BIAS [mm] is set equal to the "Height Calibration Bias" in the SDR Header (field 12).

### **2.2.12 ALTITUDE\_BIAS\_INITIAL**

ALTITUDE\_BIAS\_INITIAL [km] is set equal to the "Altitude Bias (Initial)" in the SDR Header (field 16).

### **2.2.13 ALTITUDE\_BIAS\_CENTER\_OF\_GRAVITY**

ALTITUDE\_BIAS\_CENTER\_OF\_GRAVITY [mm] is set equal to the "Altitude Bias based on S/C CG" in the SDR Header (field 17).

### **2.2.14 SWH\_BIAS\_INITIAL**

SWH\_BIAS\_INITIAL is not used at this time and is set to 0.0.

### **2.2.15 AGC\_CALIBRATION\_BIAS**

AGC\_CALIBRATION\_BIAS [dB] is set equal to the "AGC Calibration Bias" in the SDR Header (field 13).

### **2.2.16 AGC\_BIAS\_INITIAL**

AGC\_BIAS\_INITIAL [dB] is set equal to the "AGC Bias (Initial)" in the SDR Header (field 19).

2.2.17 KEYWORDS

Various Keywords are supplied in the First Comment Line (line 17) to identify which data types or models were used in the creation of the NGDR. Table 2.2.2-1 displays the Keywords, their possible values, and the corresponding NGDR Data Record fields associated with the Keywords.

KEYWORD	KEYWORD Values	NGDR Record Field
DRY	NOGAPS	<u>Dry Troposphere</u>
ION	IRI95	<u>Ionosphere</u>
	GIM (24 hour lag)	
	GIM_FL (72 hour lag)	
	GIM_ML (model)	
ORB	NAVSPASUR (ZNSA)	<u>Altitude</u>
	OODD	
	PODD	
	MOESLR	
	POESLR	
TID	FES95.2	<u>Ocean Water Tide</u>
		<u>Ocean Load Tide</u>
WET	WVR	<u>Wet Troposphere</u>

Table 2.2.17-1 Header Keywords

The Keywords can appear in any order, with each Keyword followed by an equal sign and the Keyword value. Each Keyword combination is separated from the others by a space with the last Keyword combination ending with a semicolon ";".

Example: **ORB=OODD TID=FES95.2 ION=IRI995;**

The Ionosphere Keyword Values for **GIM** are described below:

KEYWORD	Description
GIM	Initial GIM product having a 24 hour lag (with respect to the altimetry data)
GIM_FL	Final GIM product having a 72 hour lag

GIM_ML	GIM product made with a model (if no real data is available)
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Table 2.2.17-2 GIM Keywords

2.2.18 N/A

Record 18 is the second comment line of the NGDR Header and is not used at this time.

2.2.19 N/A

Record 19 is the third comment line of the NGDR Header and is not used at this time.

2.2.20 END\_OF\_HEADER

END\_OF\_HEADER is the text string used to demarcate the end (last line) of the NGDR Header.

2.3 Data Record

**Format:** Binary data in big-endian format.

**Description:**

Record #	Parameter	Units	Bytes	Type	Limits/Range
1	<u>Time Past Epoch</u>	seconds	4	Unsigned Integer	0 to 2 <sup>32</sup>
2	Time Past Epoch Continued	microseconds	4	Unsigned Integer	0 to 1E6
3	<u>Latitude</u>	microdegrees	4	Integer	+/- 72E6
4	Longitude	microdegrees	4	Integer	0 to 360E6
5	<u>SSH Uncorrected</u>	millimeters	4	Integer	-1E6 to 1E7
6	<u>SSH Corrected</u>	millimeters	4	Integer	-1E6 to 1E7
7	<u>Altitude</u>	millimeters	4	Unsigned Integer	7E8 to 9E8
8	<u>Time Shift Midframe</u>	microseconds	4	Integer	0 to 1E6
9	SWH	centimeters	2	Unsigned Integer	0 to 2500
10	Sigma0	0.01dB	2	Unsigned Integer	0 to 4000
11	<u>Wind Speed</u>	centimeters/sec	2	Unsigned Integer	0 to 7500
12	AGC	0.01dB	2	Unsigned Integer	0 to 6400
13	<u>Dry Troposphere</u>	millimeters	2	Integer	-2500 to -2200



14	<a href="#">Wet Troposphere</a>	millimeters	2	Integer	-700 to 0
15	<a href="#">Ionosphere</a>	millimeters	2	Integer	-500 to -40
16	<a href="#">Inverse Barometer</a>	millimeters	2	Integer	+/- 500
17	<a href="#">Sea State Bias</a>	millimeters	2	Integer	-1200 to 0
18	<a href="#">Solid Earth Tide</a>	millimeters	2	Integer	+/- 500
19	<a href="#">Ocean Water Tide</a>	millimeters	2	Integer	+/- 5000
20	<a href="#">Ocean Load Tide</a>	millimeters	2	Integer	+/- 500
21	<a href="#">Pole Tide</a>	millimeters	2	Integer	+/- 200
22	Water Depth	meters	2	Integer	-1 to -8000
23	Geoid Height	millimeters	4	Integer	+/- 1.5E6
24	<a href="#">Mean Sea Surface I</a>	millimeters	4	Integer	+/- 1.5E6
25	Mean Sea Surface II	millimeters	4	Integer	+/- 1.5E6
26	<a href="#">SSHU STD</a>	millimeters	2	Unsigned Integer	0 to 65534
27	SWH STD	centimeters	2	Unsigned Integer	0 to 65534
28	AGC STD	0.01 dB	2	Unsigned Integer	0 to 65534
29	<a href="#">Net Height Correction</a>	millimeters	2	Integer	+/- 16767
30	Net SWH Correction	millimeters	2	Integer	+/- 16767
31	Net AGC Correction	0.01 dB	2	Integer	+/- 16767
32	<a href="#">Net Time Tag Correction</a>	microseconds	4	Integer	0 to 1E6
33	Attitude	0.01 deg	2	Integer	+/- 80
34	<a href="#">Flags I</a>	bit pattern	2	Unsigned Integer	0 or 1
35	Flags II	bit pattern	2	Unsigned Integer	0 or 1
36	Instrument State Flags	bit pattern	1	Unsigned Integer	0 or 1
37	<a href="#">NVals SSHU</a>	N/A	1	Integer	6 to 10
38	NVals SWH	N/A	1	Integer	6 to 10
39	NVals AGC	N/A	1	Integer	6 to 10
40-49	<a href="#">SWH High-Rate (1:10)</a>	centimeters	2	Unsigned Integer	0 to 2500

50-59	SSHU High-Rate Differences (1:10)	millimeters	2	Integer	+/- 1E4
60-69	Altitude High-Rate Differences (1:10)	millimeters	2	Integer	+/- 1E4
70	<a href="#">22 GHz Brightness Temp</a>	0.01 deg K	2	Unsigned Integer	0 to 27000
71	37 GHz Brightness Temp	0.01 deg K	2	Unsigned Integer	0 to 27000
72	<a href="#">RA Status Mode I</a>	bit pattern	2	Unsigned Integer	0 or 1
73	RA Status Mode II	bit pattern	2	Unsigned Integer	0 or 1
74	<a href="#">Quality Word I</a>	bit pattern	4	Unsigned Integer	0 or 1
75	Quality Word II	bit pattern	4	Unsigned Integer	0 or 1
76	<a href="#">Receiver Temperature</a>	0.01 deg C	2	Integer	
77	Average VATT	microvolt	4	Integer	
78	Fitted VATT	microvolt	4	Integer	

Table 2.3-1 Data Record Description

Many of the fields in the NGDR Data Record are derived from (or set equal to) fields from the [SDR](#) Header and [SDR](#) Data Record.

The following sections describe the NGDR Data Record fields listed in the table above.

### 2.3.1 Time Past Epoch

Time Past Epoch [seconds] is the time at the midframe expressed as the number of integer seconds since January 1, 1985, 0.0 hours UTC. Compute the actual midframe time as follows:

Time\_Midframe [sec] =

Time\_Past\_Epoch [sec] + Time\_Past\_Epoch\_Continued [microsec] \* 1E-6

### 2.3.2 Time Past Epoch Continued

Time Past Epoch Continued [microseconds] is the fractional contribution to the total Time Past Epoch.

### 2.3.3 Latitude

Latitude [microdegrees] is the geodetic latitude calculated at the midframe, where north is positive and south is negative. This quantity is derived from an ephemeride or Keplerian elements (refer to [section 2.2.17](#) and "[ephemeris](#)" in the Glossary).

### 2.3.4 Longitude

Longitude [microdegrees] is the east geodetic longitude calculated at the midframe, where  $0 \leq \text{longitude} < 360$ . This quantity is derived from an ephemeride or Keplerian elements (refer to [section 2.2.17](#) and "[ephemeris](#)" in the Glossary).

### 2.3.5 SSH Uncorrected

SSH Uncorrected (SSHU) is the 1 per second Sea Surface Height (SSH) relative to the [ellipsoid](#), without any environmental corrections. The 1 per second value is calculated at the midframe using the 10 per second SSHU values. The 1 per second value is obtained from a linear fit with iterative outlier rejection applied to the 10 per second values.

$$\text{SSHU [mm]} =$$

$$\text{Satellite\_Altitude} - (\text{Satellite\_Range} + \text{Net\_Height\_Correction}) ,$$

where

Satellite\_Range is the uncorrected height of the satellite above the sea surface, obtained from the [SDR](#) parameters H(1) through H(10) (fields 7 through 16 of the [SDR](#) Data Record).

### 2.3.6 SSH Corrected

SSH Corrected (SSHC) is the 1 per second Sea Surface Height (SSH) relative to the [ellipsoid](#), with environmental corrections. The 1 per second value is calculated at the midframe using the 10 per second SSHC values. The 1 per second value is obtained from a linear fit with iterative outlier rejection applied to the 10 per second values. SSHC is calculated from SSHU ([section 2.3.5](#)).

$$\text{SSHC [mm]} = \text{SSHU} - \text{Environmental\_Corrections} ,$$

where

$$\text{Environmental\_Corrections} =$$

$$\text{Ionosphere} + \text{Dry\_Troposphere} + \text{Wet\_Troposphere} + \text{Inverse\_Barometer} + \text{Ocean\_Water\_Tide} + \text{Ocean\_Load\_Tide} + \text{Solid\_Earth\_Tide} + \text{Pole\_Tide} + \text{Sea\_State\_Bias}$$

### 2.3.7 Altitude

[Altitude](#) [mm] is the [geodetic height](#) of the satellite above the [reference ellipsoid](#), calculated at the midframe. This quantity is derived from an ephemeris or Keplerian elements (refer to [section 2.2.17](#) and "[ephemeris](#)" in the Glossary).

### 2.3.8 Time Shift Midframe

Time Shift Midframe is the time offset (shift) which must be added to the time of the first sample of the [SDR](#) high-rate data to obtain the time at the midframe. Times of [SDR](#) Data Records pertain to the first RA data sample of the high-rate data, while times of NGDR Data Records pertain to the midframe.

Time Shift Midframe is calculated from "Ratio" in the [SDR](#) Header (field 25) and the "Net Time Tag Correction" in the NGDR Data Record (field 32), as follows:

$$\text{Time\_Shift\_Midframe [microsec]} =$$

$$(4.5 * 0.098 * 1\text{E}6 * \text{Ratio}_{\text{SDR}}) - \text{Net\_Time\_Tag\_Correction}_{\text{NGDR}}$$

Note that the  $\text{Net\_Time\_Tag\_Correction}_{\text{NGDR}}$  is set equal to the "Time Bias (Initial)" in the [SDR](#) Header (field 18). Refer to [section 2.3.32](#).

For each SDR file which the ADFC receives during the day, its unique "Ratio" and "Time Bias (Initial)" are stored in the Oracle database. Then when an NGDR is created, the times of its records are computed using the appropriate time parameters.

### 2.3.9 SWH

SWH is the 1 per second Significant Wave Height calculated at the midframe using the 10 per second SWH's from the [SDR](#). The 1 per second value is obtained from a linear fit with iterative outlier rejection.

$$\text{SWH [cm]} = \text{SWH}_{\text{SDR}}[\text{m}] * 100$$

### 2.3.10 Sigma0

Sigma0 [0.01 dB] is set equal to the "Backscatter Coefficient" from the [SDR](#) Data Record (field 48).

### 2.3.11 Wind Speed

Wind Speed is calculated from Sigma0 using a modified Chelton Wentz algorithm:

$$\text{Wind\_Speed [cm/sec]} = 100 * \text{SUM} \{ a(\text{coeff\_index}, i) * \text{Sigma0}^{**i} \}_{i=0,1,2,3,4} ,$$

where

$$\text{coeff\_index} = 0 \text{ for } \text{Sigma0} < 11.4$$

$$\text{coeff\_index} = 1 \text{ for } 11.4 \leq \text{Sigma0} < 20.2$$

$$\text{coeff\_index} = 2 \text{ for } \text{Sigma0} \geq 20.2$$

and  $a(\text{coeff\_index}, i)$  is a 3x5 array with the following values:

$$\{ 58.7614523 , -13.58500361, 2.239083411, -0.188532055, 0.005438225 \}$$

$$\{ 366.3919346, -81.88668532, 6.890552953, -0.257760189, 0.003607894 \}$$

$$\{ 0.0 , 0.0 , 0.0 , 0.0 , 0.0 \}$$

### 2.3.12 AGC

AGC is the 1 per second Automatic Gain Control calculated at the midframe using the 10 per second AGC's from the [SDR](#). The 1 per second value is obtained from a linear fit with iterative outlier rejection.

$$\text{AGC [0.01 dB]} = \text{AGC}_{\text{SDR}}[\text{dB}] * 100 + \text{Net\_AGC\_Correction [0.01 dB]}$$

### 2.3.13 Dry Troposphere

Dry Troposphere is derived from NOGAPS surface pressure data loaded into a GIS database. The data value is determined by nearest neighbor calculations and is revised based on orbit updates. (The Dry Troposphere value is stored in the ADFC Oracle database, not the original surface pressure.)

$$\text{Dry\_Troposphere [mm]} =$$

$$-2.273_{\text{mm/mb}} * (1 + 0.0026 * \cos(2 * \text{Latitude}_{\text{radians}})) * \text{Surface\_Pressure}_{\text{NOGAPS}}[\text{mb}]$$

### 2.3.14 Wet Troposphere

Wet Troposphere is obtained from the "Path Delay" in [SDR](#) Data Record (field 49) as follows:

$$\text{Wet\_Troposphere [mm]} = -10 * \text{Path\_Delay}_{\text{SDR}} [\text{cm}]$$

### 2.3.15 Ionosphere

Ionosphere is an altimeter range correction derived from the total electron content (TEC) in the atmosphere. Ionosphere is obtained from either the IRI95 model or JPL's Global Ionosphere Maps (GIM). GIM provides a precise value based on recent measurements.

When an NGDR is created, if GIM values are available they are used. Otherwise, IRI95 values are used. Also, when converting TEC to a range correction, the frequency of the altimeter is used. For GFO the frequency is 13.495 GHz.

Ionosphere is computed as follows:

$$\text{Ionosphere [mm]} = -1 * \text{Range\_Correction}_{\text{IRI95:GIM [mm]}}$$

(Click on [GIM](#) in the Glossary and the [GIM GFO web link](#) in Appendix B for more information.)

### 2.3.16 Inverse Barometer

Inverse Barometer is calculated from the Dry Troposphere value contained in the ADFC Oracle database as follows:

$$\text{Inverse\_Barometer [mm]} = -9.948_{\text{mm/mb}} * (\text{Surface\_Pressure}_{\text{mb}} - 1013.3) ,$$

where

$$\text{Surface\_Pressure [mb]} =$$

$$\text{Dry\_Troposphere}_{\text{mm}} / (-2.273_{\text{mm/mb}} * (1 + 0.0026 * \cos(2 * \text{Latitude}_{\text{radians}})))$$

### 2.3.17 Sea State Bias

Sea State Bias (SSB) is calculated from the SWH (see section 2.3.9) as follows:

$$\text{Sea\_State\_Bias [mm]} = -0.045 * (\text{SWH}_{\text{NGDR [cm]}} * 10)$$

### 2.3.18 Solid Earth Tide

Solid Earth Tide is calculated as follows:

$$\text{Solid\_Earth\_Tide [mm]} = 1000 * (\text{RH2} * \text{V2} + \text{RH3} * \text{V3}) / \text{GRAVITY} ,$$

where

$$\text{RH2} = 0.609 , \text{RH3} = 0.291 , \text{and GRAVITY} = 9.80 .$$

V2 and V3 are the second and third degree potential values (in the MKS system) from the tide-generating potential as given by Cartwright and Tayler (1971) and corrected by Cartwright and Edden (1973).

### 2.3.19 Ocean Water Tide

Ocean Water Tide [mm] is calculated from the Grenoble FES95.2 tide database.

### 2.3.20 Ocean Load Tide

Ocean Load Tide [mm] is calculated from the Grenoble FES95.2 tide database.

### 2.3.21 Pole Tide

Pole Tide is calculated as follows:

Pole\_Tide [mm] =

$$A * \sin(2 * \text{Latitude}_{\text{radians}}) * ((\text{Polar\_location\_X} - \text{X\_pole\_avg}) * \cos(\text{Longitude}_{\text{radians}}) - (\text{Polar\_location\_Y} - \text{Y\_pole\_avg}) * \sin(\text{Longitude}_{\text{radians}}))$$

where

A = -69.435 , X\_pole\_avg = 0.042 , and Y\_pole\_avg = 0.293 .

The "Polar\_location\_X" and "Polar\_location\_Y" are the polar motion angles (in arcsec) obtained from data in the PODD or POE.

(Click [here](#) for a description of the pole tide correction.)

### 2.3.22 Water Depth

Water Depth [m] is obtained from the DBDB5 bathymetry database.

### 2.3.23 Geoid Height

Geoid Height [mm] is obtained from the EGM96 database.

### 2.3.24 Mean Sea Surface I

This is not currently implemented. Mean Sea Surface I will contain the NRL-Stennis mean sea-surface.

### 2.3.25 Mean Sea Surface II

Mean Sea Surface II [mm] is obtained from the OSUMSS95 database.

### 2.3.26 SSHU STD

SSHU STD [mm] is the standard deviation from the fit applied to the 10 per second SSHU values ([section 2.3.5](#)).

### 2.3.27 SWH STD

SWH STD [cm] is the standard deviation from the fit applied to the 10 per second SWH values (section 2.3.9).

### 2.3.28 AGC STD

AGC STD [0.01 dB] is the standard deviation from the fit applied to the 10 per second AGC values (section 2.3.12).

### 2.3.29 Net Height Correction

Net Height Correction is calculated from fields in the [SDR](#) Header and Data Record as follows:

Net\_Height\_Correction [mm] =

$$\text{Attitude\_Wave\_Height\_Bias}_{\text{SDR}} - \text{Height\_Calibration\_Bias}_{\text{SDR}} + \text{Altitude\_Bias\_Center\_of\_Gravity}_{\text{SDR}} - (1\text{E}6 * \text{Altitude\_Bias\_Initial}_{\text{SDR}}) - \text{FM\_Crosstalk}_{\text{SDR}}$$

### 2.3.30 Net SWH Correction

Net SWH Correction is calculated from the "SWH Bias" in the [SDR](#) Data Record (field 31) as follows:

$$\text{Net\_SWH\_Correction [mm]} = \text{SWH\_Bias}_{\text{SDR}}[\text{m}] * 1000$$

### 2.3.31 Net AGC Correction

Net AGC Correction is calculated from fields in the [SDR](#) Header and Data Record as follows:

$$\text{Net\_AGC\_Correction [0.01 dB]} =$$

$$\text{AGC\_Temperature\_Correction}_{\text{SDR}} + \text{Delta\_AGC\_Height}_{\text{SDR}} + \text{AGC\_Correction\_for\_Attitude}_{\text{SDR}} - \text{AGC\_Calibration\_Bias}_{\text{SDR}}$$

### 2.3.32 Net Time Tag Correction

Net Time Tag Correction [microseconds] is set equal to the "Time Bias (Initial)" in the [SDR](#) Header (field 18).

For each SDR file which the ADFC receives during the day, its unique "Time Bias (Initial)" is stored in the Oracle database. Then when an NGDR is created, the times of its records are computed using the appropriate time parameters.

### 2.3.33 Attitude

Attitude is calculated from the "Off-nadir Angle" in the [SDR](#) Data Record (field 47) as follows:

$$\text{Attitude [0.01 deg]} = \text{Off\_Nadir\_Angle}_{\text{SDR}}[\text{deg}] * 100$$

### 2.3.34 Flags I

This field is not used at this time. It will be a bit field used to indicate NGDR specific information.

### 2.3.35 Flags II

This field is not used at this time. It will be a bit field used to indicate NGDR specific information.

### 2.3.36 Instrument State Flags

This field is not used at this time. It will be a bit field used to verify that the instrument state has not changed.

### 2.3.37 NVals SSHU

NVals SSHU is the number of high-rate values used in the calculation of the 1 per second SSHU ([section 2.3.5](#)).

### 2.3.38 NVals SWH

NVals SWH is the number of high-rate values used in the calculation of the 1 per second SWH (section 2.3.9).

### 2.3.39 NVals AGC

NVals AGC is the number of high-rate values used in the calculation of the 1 per second AGC (section 2.3.12).

### 2.3.40 SWH High-Rate

SWH High-Rate is calculated from the "SWH" high-rate values in the [SDR](#) Data Record (fields 20 through 29) as follows:

$$\text{SWH\_High\_Rate}(i) [\text{cm}] = \text{SWH} \quad (i) [\text{m}] * 100 + \text{Net\_SWH\_Correction} \quad , i=1,...,10$$

The "Net\_SWH\_Correction<sub>NGDR</sub>" is detailed in section 2.3.30.

### 2.3.41 SSHU High-Rate Differences

SSHU High-Rate Differences [mm] are the differences of the high-rate SSHU values from the 1 per second SSHU value ([section 2.3.5](#)). The original high-rate SSHU values can be reconstructed by adding to them the 1 per second SSHU value.

### 2.3.42 Altitude High-Rate Differences

Altitude High-Rate Differences [mm] are the differences of the high-rate Altitude values from the 1 per second Altitude value ([section 2.3.7](#)). The original high-rate Altitude values can be reconstructed by adding to them the 1 per second Altitude value.

### 2.3.43 22 GHz Brightness Temp

22 GHz Brightness Temp is calculated from the "22 GHz Brightness Temp" in the [SDR](#) Data Record (field 50) as follows:

$$22 \text{ GHz Brightness Temp [0.01 deg K]} = 22 \text{ GHz Brightness Temp}_{\text{SDR}}[\text{deg K}] * 100$$

### 2.3.44 37 GHz Brightness Temp

37 GHz Brightness Temp is calculated from the "37 GHz Brightness Temp" in the [SDR](#) Data Record (field 51) as follows:

$$37 \text{ GHz Brightness Temp [0.01 deg K]} = 37 \text{ GHz Brightness Temp}_{\text{SDR}}[\text{deg K}] * 100$$

### 2.3.45 RA Status Mode I

RA Status Mode I is set equal to the "RA Status Mode I" from the [SDR](#) Data Record (field 2). This is a bit field.

### 2.3.46 RA Status Mode II

RA Status Mode II is set equal to the "RA Status Mode II" from the [SDR](#) Data Record (field 3). This is a bit field.

### 2.3.47 Quality Word I

Quality Word I is set equal to the "RA Quality Test Results" from the [SDR](#) Data Record (field 4). This is a bit field.

### 2.3.48 Quality Word II

Quality Word II is set equal to the "WVR Quality Test Results" from the [SDR](#) Data Record (field 5). This is a bit field.

### 2.3.49 Receiver Temperature

Receiver Temperature is calculated from the "Receiver Temperature" in the [SDR](#) Data Record (field 54) as follows:

$$\text{Receiver Temperature [0.01 deg C]} = \text{Receiver Temperature}_{\text{SDR}}[\text{deg C}] * 100$$

### 2.3.50 Average VATT

Average VATT is calculated from the "Average VATT" in the [SDR](#) Data Record (field 52) as follows:



$$\text{Average VATT [microvolt]} = \text{Average VATT}_{\text{SDR}}[\text{volt}] * 1\text{E}6$$

### 2.3.51 Fitted VATT

Fitted VATT is calculated from the "Fitted VATT" in the [SDR](#) Data Record (field 53) as follows:

$$\text{Fitted VATT [microvolt]} = \text{Fitted VATT}_{\text{SDR}}[\text{volt}] * 1\text{E}6$$

## Glossary

[\[A\]](#) [\[C\]](#) [\[D\]](#) [\[E\]](#) [\[G\]](#) [\[I\]](#) [\[J\]](#) [\[M\]](#) [\[N\]](#) [\[O\]](#) [\[P\]](#) [\[R\]](#) [\[S\]](#) [\[T\]](#) [\[U\]](#) [\[V\]](#) [\[W\]](#) [\[Z\]](#)

μ

micro (1E-6)

-A-

ADFC Altimetry Data Fusion Center

AGC Automatic Gain Control

alphanumeric Comprised of letters and/or numbers.

[Altitude](#) The [geodetic height](#) above the [reference ellipsoid](#)

ASCII American Standard Code for Information Interchange

-C-

[Cal/Val](#) Calibration and Validation

[CCAR](#) Colorado Center for Astrodynamics Research

[CIA](#) Central Intelligence Agency

[CNES](#) Centre National d'Etudes Spatiales

CRB Change Review Board

CTRS Conventional Terrestrial Reference System

-D-

DBDB5 Digital Bathymetry Data Base 5 Minute Resolution

[DEOS](#) Delft Institute for Earth-Oriented Space Research

[DORIS](#) Doppler Orbitography and Radiolocation Integrated by Satellite

DOY Day of Year

-E-

ECF Earth Centered Fixed

[EGM96](#) Earth Gravity Model 1996

ellipsoid	A mathematical figure formed by revolving an ellipse about its minor axis (also termed an oblate spheroid). Two quantities define an ellipsoid: 1) the length of the semimajor axis, $a$ , and 2) the flattening, $f = (a - b)/a$ (where $b$ is the length of the semiminor axis). The "inverse flattening" is defined as $1/f$ .
	"ellipsoid" is often used interchangeably with "reference ellipsoid".
	(See <a href="#">reference ellipsoid</a> )
<a href="#">ENVISAT-1</a>	Environmental Satellite 1
ephemerides	Plural of <a href="#">ephemeris</a>
ephemeris	An orderly list of locations (positions) of a celestial object as a function of time. The locations can refer to past, present, or future (predicted) locations.
	GFO's <a href="#">NAVSPASUR</a> ( <a href="#">ZNSA</a> ) file consists of a list of its Keplerian orbital elements from which an ephemeris can be created.
	GFO's <a href="#">OODD</a> file consists of a list of its geodetic positions (longitude, latitude, height above the <a href="#">ellipsoid</a> ) as a function of time.
	GFO's <a href="#">PODD</a> and <a href="#">POE</a> files consist of list of its Earth Centered Fixed positions (geocentric $x,y,z$ ) as a function of time.
ERM	Exact Repeat Mission
ERO	Exact Repeat Orbit
<a href="#">ERS-1/2</a>	ESA Remote Sensing Satellite 1/2
<a href="#">ESA</a>	European Space Agency (Franscati, Italy)
<a href="#">ESOC</a>	European Space Operations Centre
<a href="#">ESRIN</a>	European Space Research Institute
-G-	
GDR	Geophysical Data Record
GEM	Goddard Earth Model
geodetic height	The height above the <a href="#">reference ellipsoid</a> , measured along the <a href="#">geodetic vertical</a> at the observer's location on the earth.
geodetic vertical	The normal to the <a href="#">reference ellipsoid</a> at the observer's location on the earth.
<a href="#">GEOSAT</a>	Geodetic Satellite
<a href="#">GFO</a>	GEOSAT Follow-On
<a href="#">GIM</a>	Global Ionosphere Maps. When used as a <a href="#">Keyword</a> it pertains to GIM data with a 24 hour lag.
GIM_FL	Keyword pertaining to the final GIM product with a 72 hour lag.
GIM_ML	Keyword signifying that no GIM data was available and that JPL supplied the output

from an ionospheric model.

GMT Greenwich Mean Time (links to UTC time from [NIST](#) and [USNO](#))

[GPS](#) Global Positioning System (see [IGS](#))

[GSFC](#) Goddard Space Flight Center

-I-

IGDR Interim Geophysical Data Record. "Interim" refers to the fact that this data file is generated very soon after data acquisition so that interim values of some parameters (such as the orbit) must be used, until the full-precision values become available.

[IGS](#) International GPS Service. Provider of GPS data

[IRI95](#) International Reference Ionosphere 1995

ITOD Inertial True of Date

-J-

[Jason-1](#) The follow-on satellite to TOPEX/Poseidon

[JPL](#) Jet Propulsion Laboratory

-M-

midframe The midpoint (center) of an NGDR Data Record, i.e. the point midway in time between the fifth and six samples of the high-rate data.

MOE Medium Orbit [Ephemeris](#). Created [GSFC](#).

MOESLR MOE data obtained from SLR data.

MSS Mean Sea-Surface

-N-

N/A Not Applicable

[NASA](#) National Aeronautics and Space Administration

[NAVO](#) Naval Oceanographic Office

[NAVOCEANO](#) Naval Oceanographic Office

NAVSOC Naval Satellite Operations Center (Pt. Mugu, CA)

[NAVSPACECOM](#) Naval Space Command

NAVSPASUR Naval Space Surveillance System (now NAVSPACECOM).

For historical reasons the satellite orbital elements obtained from NAVSPASUR were referred to as "NAVSPASUR elements or files". NAVSPOC now provides these elements (see also [ZNSA](#)).

NAVSPOC Naval Space Command Operations Center (Dahlgren, VA). Provides Keplerian orbital elements for satellites of interest to the Navy.

NGDR	Navy Interim Geophysical Data Record (see <a href="#">IGDR</a> )
<a href="#">NIST</a>	National Institute of Standards and Technology
<a href="#">NOAA</a>	National Oceanic and Atmospheric Administration
<a href="#">NOGAPS</a>	Navy Operational Global Atmospheric Prediction System
<a href="#">NORAD</a>	North American Aerospace Defense Command
Nvals	Number of Values
-O-	
OODD	Operational Orbit Determination Data. Created <a href="#">NAVSOC</a> .
OOE	Operational Orbit <a href="#">Ephemeris</a>
OOESLR	OOE data obtained from SLR data.
Orbit	Depending on the context this may refer to a satellite's 1) path in space, 2) <a href="#">ephemeris</a> , or 3) <a href="#">altitude</a> .
OSUMSS95	Ohio State University Mean Sea-Surface 1995
-P-	
POC	Payload Operations Center
PODD	Precision Orbit Determination Data. Created <a href="#">NAVSOC</a> .
PODPS	Precision Orbit Determination Production System
POE	Precision Orbit <a href="#">Ephemeris</a> . Created by <a href="#">GSFC</a> .
POESLR	POE data obtained from SLR data.
-R-	
RA	Radar Altimeter
reference ellipsoid	An ellipsoid created/used for geodesic measurement purposes (i.e. locating or positioning points on the surface of the Earth).

In satellite geodesy, a reference ellipsoid can be thought of as a low order ("smooth") approximation to the shape of the Earth (or to the Earth's equipotential gravity surface which most closely matches mean sea-level), where the semimajor axis is taken to lie along the rotation axis of the Earth.

The table below lists the parameters of the reference ellipsoids used for several satellites:

Satellite	Semimajor Axis [meters]	Inverse Flattening (1/f)
ERS-1 , ERS-2	6378137.0	298.257
GFO	6378136.3	298.257

TOPEX/Poseidon	6378136.3	298.257
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Click [here](#) for information on the TOPEX/Poseidon reference ellipsoid.

(See [ellipsoid](#))

REV Revolution

-S-

[SDR \(Sensor Data Record\)](#)

[Seasat-A](#) Sea Satellite ([link to Seasat page at JPL](#))

Sigma0 Backscatter Coefficient

[SLR](#) Satellite Laser Ranging

SSB Sea State Bias

SSH Sea-surface Height (relative to the [reference ellipsoid](#))

[SSHC](#) Sea-surface Height Corrected

SSHR Sea-surface Height Residual (relative to a reference surface). An example of this type of residual would be "SSHR = SSHC - MSS".

[SSHU](#) Sea-surface Height Uncorrected

STD Standard Deviation

SWH Significant Wave Height

[SWS](#) Surface Wind Speed

-T-

TEC Total Electron Content

[TLE](#) Two Line Element. A list of Keplerian orbital elements formatted as two lines of alphanumeric text.

[TOPEX](#) Ocean Topography Experiment

-U-

[USNO](#) United States Naval Observatory

[UTC](#) Universal Time Coordinated (links to UTC time from [NIST](#) and [USNO](#))

-V-

VATT Voltage Proportional to Attitude

-W-

WDBII World Data Bank II. A one-minute resolution landmask based on the CIA World Vector Shoreline.

<a href="#"><u>WS</u></a>	Wind Speed
WSC	War Fighting Support Center
WVR	Water Vapor Radiometer
WVS	World Vector Shoreline
-Z-	
ZNSA	A set of Keplerian orbital elements from NAVSPOC (see also <a href="#"><u>NAVSPASUR</u></a> ).

## **APPENDIX A : Computing Times of High-Rate Data**

To compute the 10 high-rate times for any of the high-rate data (from timing information available in the NGDR) proceed as follows:

Define the variables:

TIME\_MID = time at the midframe of the data record  
 TIME\_INC = time increment (separation) of high-rate data points  
 TIME\_10HZ(I) = array of high-rate times (size=10)

Set their values:

$TIME\_MID = Time\_Past\_Epoch + Time\_Past\_Epoch\_Continued * 1E-6$

(Using fields 1 and 2 of the Data Record from [section 2.3](#))

$TIME\_INC = (Time\_Shift\_Midframe + Net\_Time\_Tag\_Correction)/4.5$

(Using fields 8 and 32 of the Data Record from [section 2.3](#))

(This equation reduces to  $TIME\_INC = 0.098 * 1E6 * Ratio_{SDR}$  (see [section 2.3.8](#)))

DO I = 1,10

$TIME\_10HZ(I) = TIME\_MID + TIME\_INC*(I-5.5)$

ENDDO

## **APPENDIX B : GEOSAT Follow-On Web Links**

### **1.0 GFO Home Pages**

#### [NOAA](#)

<http://www.star.nesdis.noaa.gov/sod/lisa/GFO/>

#### [Ball Aerospace](#)

<http://www.ball.com/aerospace/gfohome.html>

#### [NASA JPL Quicklook](#)

<http://msl.jpl.nasa.gov/QuickLooks/gfoQL.html>

[NASA WFF](#)

<http://gfo.wff.nasa.gov/>

## **2.0 GFO Applications**

[CCAR GFO Precision Orbit Determination](#)

[http://www-ccar.Colorado.EDU/research/gps/html/gps\\_gfo.html](http://www-ccar.Colorado.EDU/research/gps/html/gps_gfo.html)

[NASA GFO Satellite Laser Ranging](#)

<http://www-csbe.atsc.allied.com/slr/gfo.htm>

[NASA JPL GFO Global Ionosphere Maps](#)

<http://iono.jpl.nasa.gov/gfo.html>

[NRL Real Time Ocean Environment](#)

<http://www7300.nrlssc.navy.mil/altimetry/>

[OSU GFO Data and Orbit Verification](#) (UNDER CONSTRUCTION)

<http://www.geodesy.eng.ohio-state.edu/gfo.html>

## **3.0 GFO Related Sites**

[NASA GSFC /OSU /NIMA GEOSAT Orbit Error Predictions with Different Gravity Models](#)

<http://cddisa.gsfc.nasa.gov/926/egm96/orberr.html>

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